

**Nuclear Safeguards and Security:  
Messübungen Für Die Allgemeine Gamma Spektroskopie, ITU 2008.**

# **NUCLEONICA: A WEB PORTAL FOR THE NUCLEAR SCIENCES**

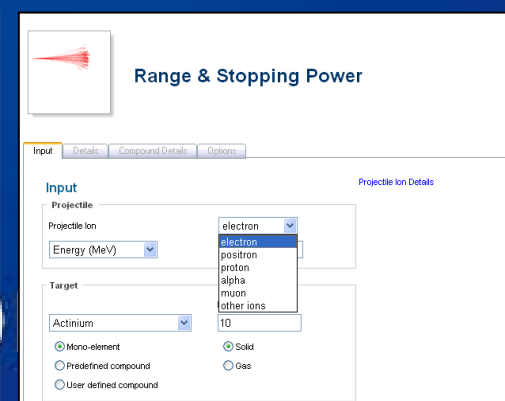
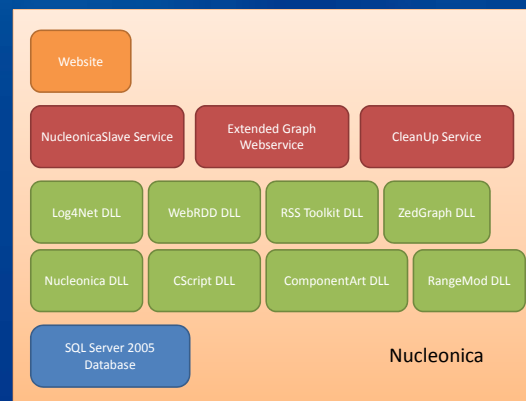
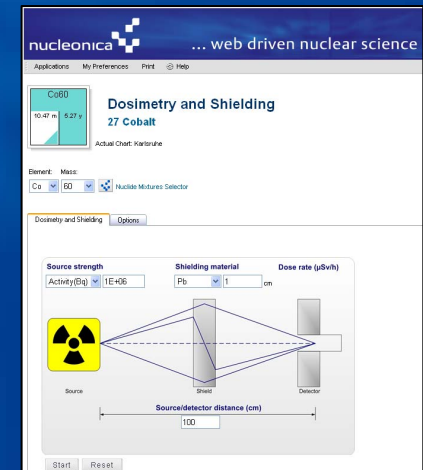
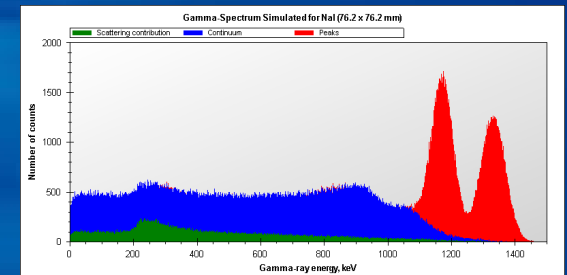
**J. MAGILL**

*European Commission, Joint Research Centre,  
Institute for Transuranium Elements,  
Postfach 2340, 76125 Karlsruhe, Germany*

**nucleonica** 

# NUCLEONICA:

- OVERVIEW
- AN INTERACTIVE WEB ACCESSIBLE GAMMA-SPECTRUM SIMULATION
- INTERACTIVE, WEB-BASED DOSIMETRY AND SHIELDING CALCULATIONS WITH NUCLEONICA
- RANGE AND STOPPING POWER CALCULATIONS IN NUCLEONICA
- NUCLEONICA – SOFTWARE DESIGN PATTERNS
- NUCLEONICA SCRIPTING
- THE KARLSRUHE NUCLIDE CHART: An educational tool for the nuclear science community





... web driven nuclear science

Sunday, November 18, 2007

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Welcome

**Products & Prices**

Free Access

Training Courses

Educational Resources

Karlsruhe Nuclide Chart

News Releases

Ask an Expert

About Us

Contact

## Nucleonica - web driven nuclear science



NUCLEONICA is a new nuclear science web portal from the European Commission's Joint Research Centre. The portal provides a customisable, integrated environment and collaboration platform for the nuclear sciences using the latest internet "Web 2.0" dynamic technology.

NUCLEONICA is aimed at professionals, academics and students working with radionuclides in fields as diverse as the life sciences (e.g. biology, medicine, agriculture), the earth sciences (geology, meteorology, environmental science) and the more traditional disciplines such as nuclear power, health physics and radiation protection, nuclear and radiochemistry, and astrophysics. It is also used as a knowledge management tool to preserve nuclear knowledge built up over many decades by creating modern web-based versions of so-called legacy computer codes.

NUCLEONICA provides "software as a service" on the web rather than through installed software, adding a greater level of stability and security and avoiding version compatibility and update problems. In addition, all NUCLEONICA's web applications are browser and operating system independent and can therefore be accessed by most web browsers.

NUCLEONICA offers the following main features:

- » **Data Centre:** Online interactive nuclide charts. Reference data and searchable databases for internationally evaluated nuclear data. Library creation software

### NUCLEONICA HOT TOPICS

» **Open Call for JRC Traineeships**

November 14, 2007

ITU's first open call for JRC-Traineeships has been published on our website. The deadline for applications is 6 December 2007 (midnight). In particular we have a position for assistance in the development of an electronic version of the Karlsruhe

### NUCLEAR NEWS

**French FM: France is not ruling out a military strike on Iran**

**NOV 18** Even though in Tehran the IAEA's report was described as a "political victory" that may prevent the intensifying of international sanctions, Kouchner says that "for now Iran persists in not meeting it [...]"

**Iran: UNSC interference illegal**

**NOV 18** Mohammad Saeedi, a senior Iranian nuclear official has said insistence on pursuing Iran's nuclear program at the Security Council lacks legal grounds, PressTV reported. [...]

**Iran says ready to act if attacked ...**

**NOV 18** LONDON, November 18 (IranMania) - Hardline Iranian President Mahmoud Ahmadinejad said Iran was ready to respond if attacked, but played down the prospect of war with the United States, Reuters reports [...]

**'Safe' uranium that left a town contaminated**

**NOV 18** It is 50 years since Tony Ciarfello and his friends used the yard of a depleted uranium weapons factory as their playground in Colonie, a suburb of Albany in upstate New York state. "There wasn't no f [...]"

**Chavez dealing pain to Spain**

**NOV 18** Chavez, who has nationalised large parts of the economy this year under his self-styled socialist "revolution", said last week he will revise diplomatic and business ties with the



**JRC**  
EUROPEAN COMMISSION




Institute for  
Transuranium  
Elements

# Nuclear Science Data & Applications

# Nucleonica Wiki (CMS)

# Networking with Nucleonica

# Training Courses




**Nucleonica Engineer**

> Actual Chart: Half-life

---

**Search Reference Documentation**

☒ Nucleonica Database

**➤ Application Centre**

- Moss Activity Calculator
- Decay Engine
- Dosimetry & Shielding
- Range & Stopping Power
- watcORfEND
- Universal Nuclide Chart
- Transport & Packaging
- Nuclide mixtures
- Nucleonica Scripting
- Library routine for 3rd party software
- Radiological Dispersion Module
- Extended Graph Module

**➤ Data Centre**

- Physical Constants
- Nuclide Databases
- Nuclide Derived Data
- Average Cross Sections
- Radiations
- Prompt Gamma
- Fission Yields

**➤ Knowledge Centre**

- Nuclear News
- Reading room
- Useful Websites
- Ask An Expert
- Element Information
- Conference Calendar

**Work online, free**

☒ Self Helpnotes    Administration

☒ Community Portal

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**➤ My Last Readings**

- ☒ 94 Pu201
- ☒ 94 Pu208
- ☒ 94 Pu238
- ☒ 41 C13

**➤ My Recent Mistakes**

- ☒ Pu238 Decay 2007
- ☒ Ca137 half life
- ☒ Decay Engine Result
- ☒ radonconcentration Source 1976
- ☒ Decay Engine Result (1)

**➤ My Sources**

☒ rules

**➤ My Messages**

- ☒ Operational for JRC Workshops at the Institute for Transuranium Elements
- ☒ HANAL-3 International Conference on Nuclear Analytical Methods in the Life Sciences
- ☒ Request for photos of non-stable elements
- ☒ report
- ☒ Open positions at the University of Lige

**➤ Best Alerts**

☒ View all

**Subadditive Decay Chains**

It is very often the case that a decay product of a nuclear decay is itself radioactive. In such cases one speaks of subadditive decay "chains" and, for example, considers the decay series  $^{238}\text{U} \rightarrow \dots \rightarrow \text{stable}$  or, in other words the "natural" nuclei, which in the "daughter"  $^{238}\text{U}$ . This daughter in turn is radioactive and decays to  $^{234}\text{Th}$ , then generally and finally to the stable nucleus  $^{206}\text{Pb}$ . (See also Fig. 1.) One can't have any less than one daughter. In addition, there may be several "daughters" for the products of the decay from the decay of the parent. The question for radioactive substances decay is then characterized by the *general* problem of subadditive decay, which was investigated systematically by Steinitz (Proc. Camb. Phil. Soc. [1950] 43; see also Steinitz, K. et al., *Ann. Physik* [1959] 17, 194; 1960).

[illegible]

**October 2007 Karlsruhe**



Nuclear Science Summer Course with Neutronics, 25/26th Oct. 2007, [Hofmannsdorf, Karlsruhe](#)

The 10th Nuclear Science summer course in Radioactivity, Radiobiology and Radiation with Neutronics was held at Hofmannsdorf, Karlsruhe from the 25th to the 26th October. This one-day course provided a general introduction to the recently advanced Neutronics, the new science combining all applications of neutrons in power and research as well as basic software package for the nuclear science community. With examples and exercises, a variety of core and applied issues in nuclear science and technology were presented by experts in their respective fields.

A total of twenty-nine participants, around half of them seniors, with a diverse range of backgrounds attended the course. There were participants from Australia, Belgium, Canada, Republic, Czech Republic, Poland, Romania and Turkey - in addition there were 10 participants from the Institute for Neutronics and Reactor Physics among them, students and industry professionals from fields such as nuclear medicine, radiation protection, environmental radiotoxicity and reactor physics.

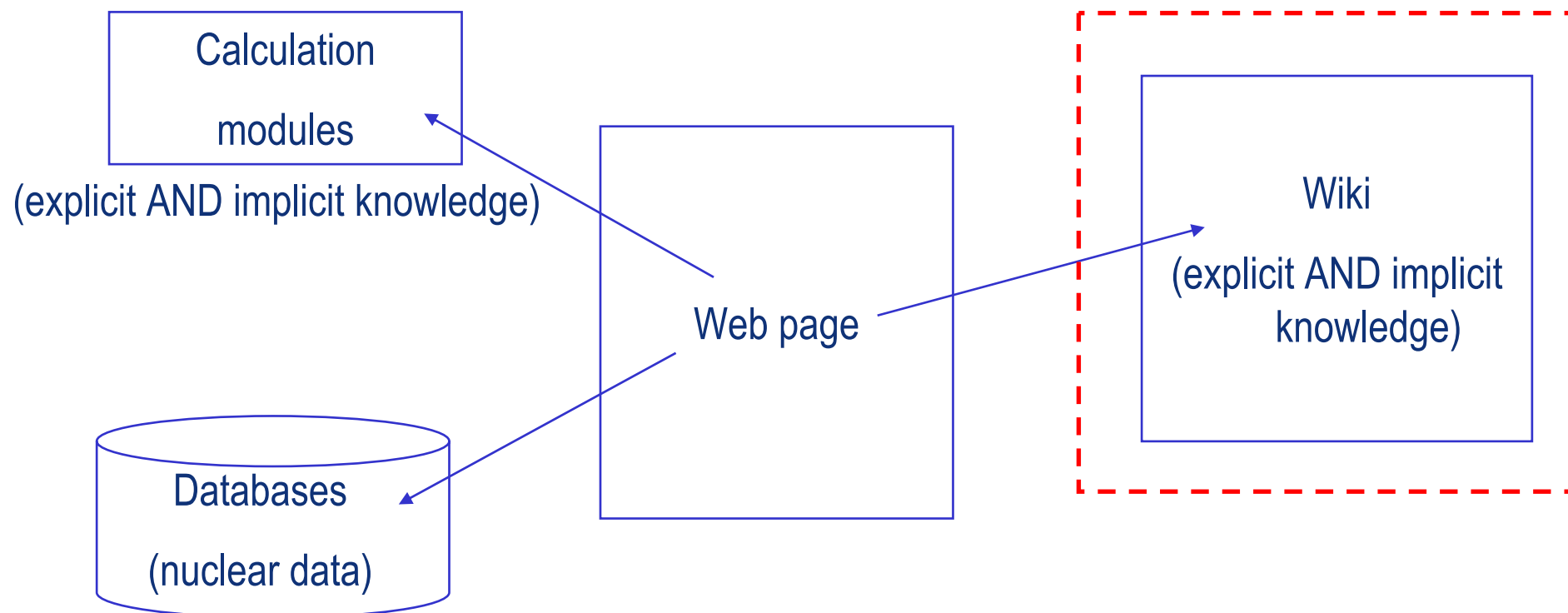
Few Agenda 2007 topics:

- How we got from the fossil to the contemporary history context
- Links to the generations and exercises
- Networking with Neutronics (A. Magaly) Exercises
- Nuclear Data (C. Vayns) Exercises
- Particle Chain (Ch. Bernhart) Exercises
- Decay Equations (Ch. Bernhart) Exercises
- Discovery & Modeling (J. Gato) Exercises
- Fuel Cycle (Ch. Bernhart) Exercises
- Nuclear Forensics & Abuse Trafficking (Ch. Mayado) Exercises
- Overview of the Institute for Transuranium Elements (F. Wastny)
- Advanced Neutronics Features (J. Magly)



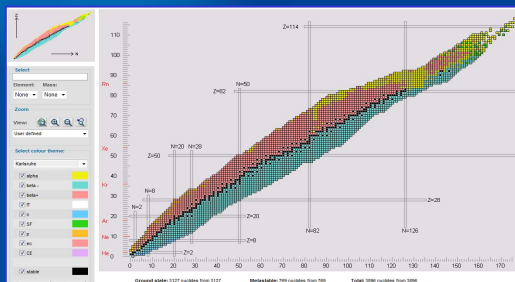
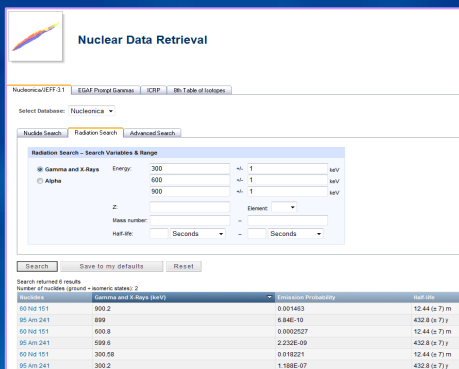
Training Course Feedback  
 CME Certificate  
 List of Participants  
 List of Certificates

## Nucleonica Architecture & Logical Structure...



**The NUCLEONICA Structure**

## Data centre...



# Nuclear science portal ...

**nucleonica** ... web driven nuclear science

Applications | My Preferences | Help | New Alerts

**Nuclide Explorer**

**Application Centre**

- Mass Activity Calculator
- Decay Engine
- Dosimetry & Shielding
- Range & Stopping Power
- webKORIGEN
- Universal Nuclide Chart
- Transport & Packaging
- Nuclide mixtures
- Nucleonica Scripting
- Library creation for 3rd party software
- Radiological Dispersion Module
- Extended Graph Module

**Search Nucleonica Documentation**

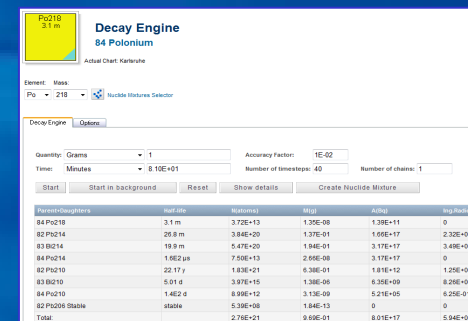
**Data Centre**

- Physical Constants
- Nuclide Datasheets
- Nuclide Derived Data
- Average Cross Sections
- Radiations
- Prompt Gamma
- Fission Yields

**Knowledge Centre**

- Nuclear News
- Reading room
- Useful Weblinks
- Ask An Expert

## Applications centre...



## Knowledge centre...

**nucleonica [wiki]**

ReadingRoom: Gallery of Nuclear Science

Contents (new)

- Actinide Science
- Nuclear Science Historical
- Nuclear Science in Karlsruhe
- Karlsruhe Nuclide Chart, 7th Edition, 2006

**Actinide Science**

from the Actinide Group, Institute for Transuranium Elements...

Sample of refined americium metal condensed on a tantalum disc (SPINEL, 1991), copyright EC-JRC-ITU

Curium metal produced by the Actinide Group, Institute for Transuranium Elements

Protactinium: Courtesy of the Actinide Group

Uranium metal cube, Institute for Transuranium Elements

## Networking centre...

**Nucleonica Networking**

Start | My Profile | My Contacts | My Mailbox | My Groups

**Free Applications**

- Forum
- Conference Calendar
- Graphics Module

**Upgrade Applications**

- nuclear science

**Coming soon**

- Open call for JRC Traineeships
- Review of Nucleonica in NVS news 2007/3
- Proceedings of the 9th Nucleonica Training Course now available

**Open Call for JRC Traineeships**

November 14, 2007

EU's first open call for JRC Traineeships has been published on our website. The deadline for applications is 6 December 2007 (midnight). In particular we have a position for assistance in the development of an electronic version of the Karlsruhe Nuclide Chart. For more details...

**US talks tough over Iran, warns China**

The US has pledged to step up to drive for new UN sanctions on Iran and warned China against sticking diplomatic efforts to halt the Islamic republic's nuclear ambitions.

Source: expressindia Language: EN Date: 2007-11-15T07:41+0100

**North and South Korea to launch regular cross-border train service**

The train service, limited to freight, will launch next month for the first time in more than half a century.

Source: HT Language: EN Date: 2007-11-15T07:31+0100

**US talks tough on Iran, warns China**

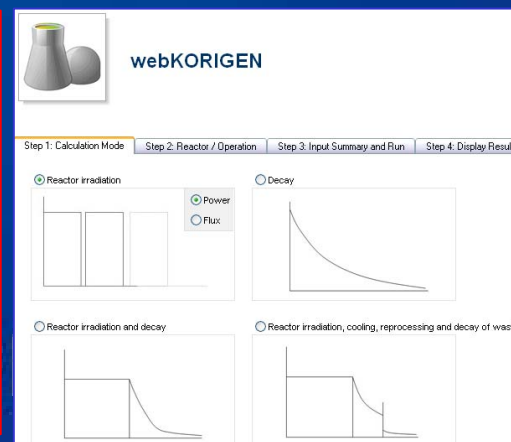
WASHINGTON (AFP) - The United States accused Iran Thursday of "drifting along" UN watchdogs investigating its nuclear ambitions and bluntly warned China not to block new sanctions against the Islamic republic.

Source: ap-english Language: EN Date: 2007-11-15T07:10+0100


**IAEA gives clean bill to Iran on its plan**

Web posted at: 11/16/2007 8:12:22 Source: AP Vienna A report from the UN nuclear watchdog agency yesterday found Iran to be generally truthful about key aspects of its nuclear history, but it warned that its knowledge of Tehran's present atomic work was shoddy.

Source: theepicentre Language: EN Date: 2007-11-15T06:59+0100



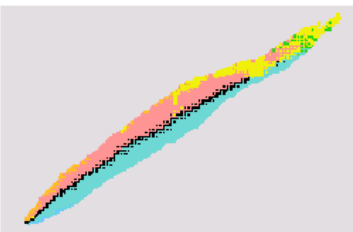
# Nuclear science applications...



## ... web driven nuclear science


Applications My Preferences Help


### > Nuclide Explorer



» Actual Chart: Karlsruhe

### > Search Nucleonica Documentation

 Nuclear Data Retrieval



### > Application Centre

- » Mass Activity Calculator
- » Decay Engine
- » Dosimetry & Shielding
- » Range & Stopping Power
- » webKORIGEN
- » Universal Nuclide Chart
- » Transport & Packaging
- » Nuclide mixtures
- » Nucleonica Scripting
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- » Radiological Dispersion Module
- » Extended Graph Module

### > Data Centre

- » Physical Constants
- » Nuclide Datasheets
- » Nuclide Derived Data
- » Average Cross Sections
- » Radiations
- » Prompt Gamma
- » Fission Yields

### > Knowledge Centre






- » Nuclear News
- » Reading room
- » Useful Weblinks
- » Ask An Expert
- » Element Information
- » Conference Calendar

### Welcome, Joe






[Edit Preferences](#) [Administration](#)

MyCommunity Portal



### > My Last Nuclides

-  90 Th232
-  90 Th231
-  94 Pu239
-  92 U235
-  25 Mn52






### > My Nuclide Mixtures

-  Pu238+daughter (100g @50y)
-  Natural Uranium
-  Cs137 + Ba137m
-  U232+Co60
-  Transuranics in 1 ton Spent Fuel (4.2% enriched, 50GWd/t, 6 years cooling)

### > My Sources


-  Pu239 1 g
-  natu

### > My Messages

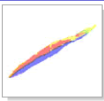
-  Thanks!
-  About my group and information
-  Photo Change
-  Open call for JRC Traineeships at the Institute for Transuranium Elements
-  NAMLS-9 International Conference on Nuclear Analytical Methods in the Life Sciences

» View

### > User Alerts

-  Task completed (DecayEngine: Uranium 238)

» View



## Nuclear Data Retrieval

Nucleonica/JEFF-3.1 EGAF Prompt Gammas ICRP 8th Table of Isotopes

Select Database: Nucleonica

Nuclide Search Radiation Search Advanced Search

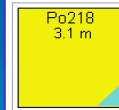
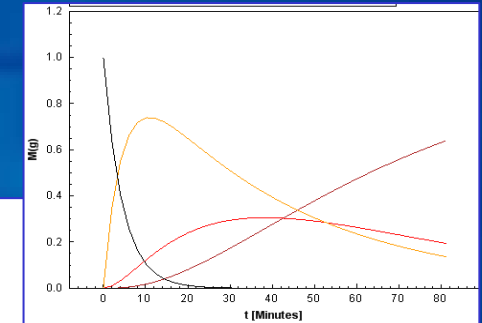
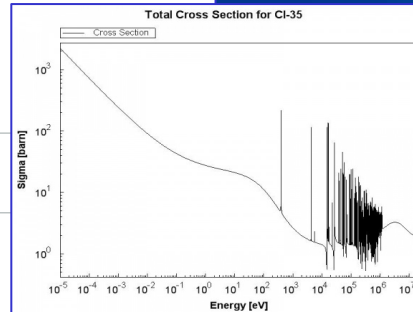
### Radiation Search - Search Variables & Range

☒ Gamma and X-Rays Energy: 300 +/- 1 keV  
☐ Alpha Energy: 600 +/- 1 keV  
Z: Mass number: Half-life: Seconds

Search Save to my defaults Reset

Search returned 6 results  
Number of nuclides (ground + isomeric states): 2

Nuclides	Gamma and X-Rays (keV)	Emission Probability	Half-life
60 Nd 151	900.2	0.001463	12.44 (± 7) m
95 Am 241	899	6.84E-10	432.8 (± 7) y
60 Nd 151	600.8	0.0002527	12.44 (± 7) m
95 Am 241	599.6	2.232E-09	432.8 (± 7) y
60 Nd 151	300.58	0.018221	12.44 (± 7) m
95 Am 241	300.2	1.188E-07	432.8 (± 7) y



## Decay Engine 84 Polonium

Actual Chart: Karlsruhe

Element: Mass:

Po 218

Nuclide Mixtures Selector

Decay Engine Options

Quantity: Grams 1 Accuracy Factor: 1E-02  
Time: Minutes 8.10E+01 Number of timesteps: 40 Number of chains: 1

Start Start in background Reset Show details Create Nuclide Mixture

Parent+Daughters	Half-life	N(atoms)	M(g)	A(Bq)	Ing.Radiot(Sv)
84 Po218	3.1 m	3.72E+13	1.35E-08	1.39E+11	0
82 Pb214	26.8 m	3.84E+20	1.37E-01	1.66E+17	2.32E+07
83 Bi214	19.9 m	5.47E+20	1.94E-01	3.17E+17	3.49E+07
84 Po214	1.6E2 µs	7.50E+13	2.66E-08	3.17E+17	0
82 Pb210	22.17 y	1.83E+21	6.38E-01	1.81E+12	1.25E+06
83 Bi210	5.01 d	3.97E+15	1.38E-06	6.35E+09	8.26E+00
84 Po210	1.4E2 d	8.99E+12	3.13E-09	5.21E+05	6.25E-01
82 Pb206 Stable	stable	5.39E+08	1.84E-13	0	0
Total:		2.76E+21	9.69E-01	8.01E+17	5.94E+07



## Dosimetry and Shielding 27 Cobalt

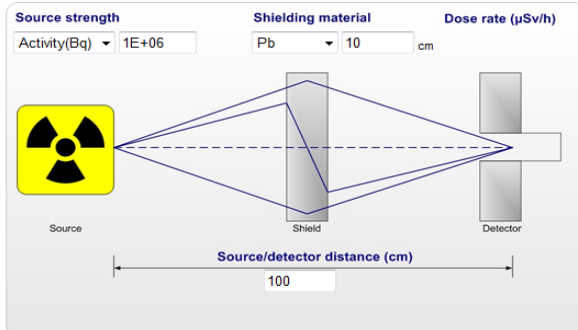
Actual Chart: Karlsruhe

Element: Mass:

Co 60

Nuclide Mixtures Selector

Dosimetry and Shielding Options



Start Reset

Half-Value Shield Thickness(cm) 1.88E+00  
Tenth-Value Shield Thickness(cm) 4.90E+00

# nucleonica


















Community Members

Pending Contacts

all Users

my Contacts


Image	Name	Organization
	MARTINA ADORNI	University of Pisa - DIMNP - GRNSPG
	Aleksandra Schwenk-Ferrero	Forschungszentrum Karlsruhe - Institute for
	Mikael Andersson	Westinghouse Electric Sweden AB
	Martin Badertscher	
	Remigiusz Baranczyk	European Commission DG TREN
	Enrico Barbina	Nabla Progetti Srl
	Valerio Barbina	Nabla Progetti Srl
	Bjoern Becker	Forschungszentrum Karlsruhe GmbH, Institut
	Fabio Belloni	European Commission, DG-JRC, Institute fo
	Andrey Berlizov	Institute for Transuranium Elements, EC JRC
	Yuri Bilodid	Forschungszentrum Dresden-Rossendorf
	Emilie BOSSE	CEA
	Berkan Cetinkaya	Ege University, Institute of Nuclear Sciences
	Vanessa Chisté	
	Catalina Chitu	

Profile

Contacts

Simon Jerome

National Physical Laboratory



[Send message](#)  
[Add to Your Contact List](#)

Name	Simon Jerome
Location	United Kingdom
Nationality	British
Organization	National Physical Laboratory
Job Title	Head of Radiochemistry
Areas Of Interest	Radiochemistry; Analytical Chemistry; Radiochemical Analysis; Low-level radioactivity measurement; Inter-laboratory comparisons and proficiency testing; ISO 17025:2005 Technical Assessor; ISO Guide 43
E-Mail	simon.jerome@npl.co.uk
Organization	Loughborough University
Address	Ashby Road Loughborough Leics LE11 3TU UK
Job Title	Lecturer in Radiochemistry
Areas Of Interest	Migration of radionuclides in the environment Effect of organics, natural and anthropogenic, on radionuclide transport
Latest Publications	Muhammad Haleem Khan, Peter Warwick and Nick Evans, Spectrophotometric Determination of Uranium with Arsenazo-III in Perchloric Acid, Chemosphere, 63, 2006, p 1165  Peter Warwick, Nick Evans and Sarah Vines, Studies on some divalent Metal a-Isosaccharinic Acid Complexes, Radiochimica Acta, 94(6-7), 2006, pp 363-369.  S. Aldridge, P. Warwick, N. Evans and S. Vines., Degradation of tetraphenylphosphonium bromide at high pH and its effect on radionuclide solubility, Chemosphere, 66(4), 2007, pp

## October 2007 Karlsruhe

[edit]

### 9th Nuclear Science Training Course with Nucleonica, 25/26th Oct. 2007, Ostendorfhaus, Karlsruhe

The 9th Nuclear Science training course on Radioactivity, Radionuclides and Radiation with Nucleonica was held at the Ostendorfhaus, Karlsruhe from the 25th to 26th October, 2007. The two-day course provided a general introduction to the recently released Nucleonica: the new science networking and applications portal. Nucleonica is a powerful and versatile web-based software package for the nuclear science community. With examples and exercises, a variety of core and topical issues in nuclear science and technology were presented by experts in their respective fields.

A total of twenty-nine participants, around half of them women, with a diverse range of backgrounds attended the course. There were participants from Azerbaijan, Belgium, Bulgaria, Czech Republic, Poland, Romania and Turkey. In addition there were 10 participants from the Institute for Transuranium Elements. Among them were students, academics and industry professionals from fields such as nuclear medicine, radiation protection, environmental radioactivity and reactor physics.

[Final Agenda 25th Oct. 2007](#)

[How to get from the hotel to the conference training centre](#)

[Links to the presentations and exercises:](#)

[Networking with Nucleonica \(J. Magill\) Exercises](#)

[Nuclear Data \(J. Galy\) Exercises](#)

[Nuclide Charts \(C. Normand\) Exercises](#)

[Decay Engine \(A. Berlizov\) Exercises](#)

[Dosimetry & Shielding \(J. Galy\) Exercises](#)

[Nuclear Forensics & Illicit Trafficking \(K. Mayer\) Exercises](#)

[Overview of the Institute for Transuranium Elements \(F. Wastin\)](#)

[Advanced Nucleonica Features \(J. Magill\)](#)

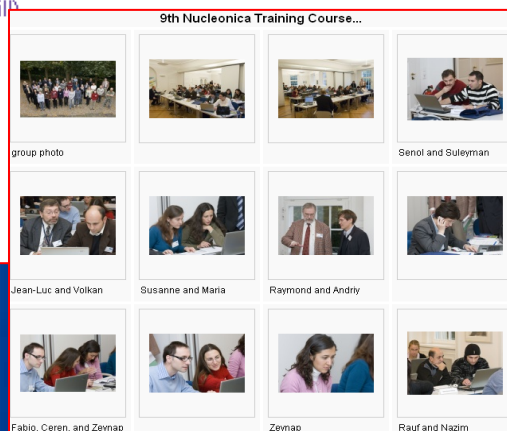
[Training Course Feedback](#)

[QM Questionnaire](#)

[Course Certificate](#)

[List of Participants](#)

[Gallery](#)



nucleonica

# WEB-BASED DOSIMETRY AND SHIELDING CALCULATIONS IN NUCLEONICA



The intuitive interface of the Dosimetry and Shielding module allows quick and accurate calculations and has been specifically designed to be suitable for use by professionals and students in the nuclear science and technology field.

The dose rate is calculated using the point source kernel approach and is given by:

$$\frac{dH(r)}{dt} = \frac{A}{4\pi r^2} \cdot \sum_i \left[ E_i \cdot P_i \cdot \left( \frac{\mu}{\rho} \right)_i^{tissue} \cdot B_i \cdot \exp \left[ - \left( \frac{\mu}{\rho} \right)_i^{shield} \cdot \rho d \right] \right]$$

## Main interface

## Options/Modes of operation

Source:

Source strength:

**Source strength**

Activity(Bq) ▼

Activity(Bq)

Activity(Ci)

Mass(g)

Atoms

**Dosimetry and Shielding**

27 Cobalt

Actual Chart: Karlsruhe

Element: Co Mass: 60 Nuclide Mixtures Selector

Dosimetry and Shielding Options

**Dosimetry and Shielding Settings**

Energy range option:

☐ Only Gamma ☐ Only X-rays ☒ Gamma and X-rays

Mode of operation option:

☒ Gamma Dose Rate ☐ ShieldThickness

Threshold energy (keV): 15

Result Detail option: ☐ Show Nuclides

**Source strength**

Activity(Bq) ▼ 1E+06

**Shielding material**

Pb ▼ 10 cm

**Dose rate (μSv/h)**

Source

Shield

Detector

Source/detector distance (cm)

100

Start Reset

**Shielding material**

Pb ▼ 10 cm

Pb

Concrete

Fe

Sn

W

U

Water


Al

Air

Tissue

# Source selection

Mixtures:



## Nuclide mixtures

---

Nuclide mixtures

**User defined nuclide mixtures**

TU & FPs 1 ton Spent Fuel (4.2% enriched, %50GWd/t, 6 years cooling)

Restore Predefined Nuclides

Create

Edit

Delete

Save

Cancel

☐ Show Details

Name

TU & FPs 1 ton Spent Fuel (4.2% enriched, %50GWd/t, 6 years cooling)

Element	Isotope	Mass
Ac	206	Grams

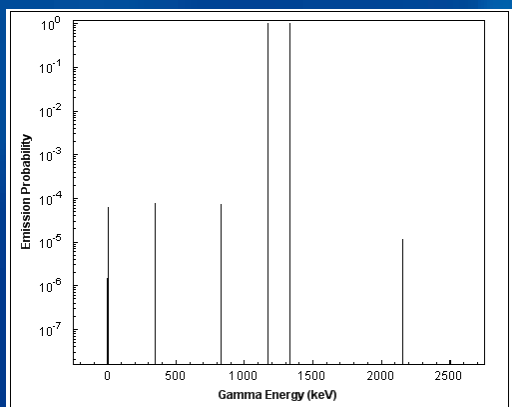
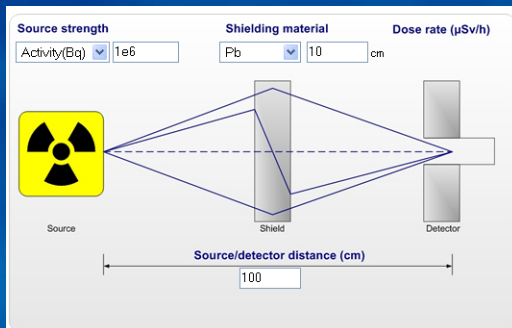
Add

Remove

Remove All

	Nuclide	Activity(Bq)	Mass(g)
Edit	93 Np237	1.9374E+10	7.4300E+2
Edit	94 Pu238	2.0339E+14	3.2100E+2
Edit	94 Pu239	1.3539E+13	5.9000E+3
Edit	94 Pu240	2.2417E+13	2.6700E+3
Edit	94 Pu241	4.7865E+15	1.2500E+3
Edit	94 Pu242	1.1383E+11	7.7800E+2
Edit	95 Am241	5.9462E+13	4.6900E+2
Edit	95 Am243	1.2931E+12	1.7500E+2
Edit	96 Cm244	1.6560E+14	5.5000E+1
Edit	96 Cm245	1.5875E+10	2.5000E+0
Edit	96 Cm246	3.4094E+10	3.0000E+0
Edit	55 Cs134	1.4776E+15	3.0890E+1
Edit	55 Cs137	1.7335E+15	5.3900E+2
Edit	38 Sr90	3.4407E+15	6.7330E+2
Edit	39 Y90	3.3982E+15	1.6890E-1
Edit	51 Sb125	1.6719E+14	4.3550E+0
Edit	61 Pm147	1.0502E+15	3.0600E+1
Edit	44 Ru106	3.7464E+15	3.0600E+1
Edit	63 Eu154	3.3983E+14	3.3980E+1
Edit	36 Kr85	3.3787E+14	2.3320E+1
Edit	58 Ce144	2.4253E+14	2.0590E+0

# Results:



Half-Value Shield Thickness(cm)	1.88E+00
Tenth-Value Shield Thickness(cm)	4.90E+00
Equivalent Dose Rate Constant $\Gamma$ (mSv·m <sup>2</sup> /GBq/h)	3.37E-01
Gamma Dose Rate (μSv/h)	1.68E-03

Download ☒ Excel ☐ CSV Separator: Semicolon (",") ☒ Use field qualifier (")

Number of lines (γ):	6	ΣE.P.(γ):	2.50E+06
Number of lines (X):	4	ΣE.P.(X):	8.35E-01
Number of lines (γ+X):	10	ΣE.P.(total):	2.50E+06

Download ☒ Excel ☐ CSV Separator: Semicolon (",") ☒ Use field qualifier (")

Component	Activity	Mass
27 Co 60	1.00E+06	2.39E-08

Nuclide	Gamma Energy (MeV)	Emission Probability P (per disintegration)	Mass Attenuation Coefficient (shielding)(cm <sup>2</sup> /g)	Number of Mean Free Path (μd)	Build-up Factor	Mass Absorption Coefficient (tissue)(cm <sup>2</sup> /g)	Gamma Dose Rate (μSv/h)
27 Co 60	1.33E+00	1.00E+00	5.64E-02	6.40E+00	3.68E+00	2.89E-02	1.08E-03
27 Co 60	1.17E+00	9.99E-01	6.20E-02	7.04E+00	4.30E+00	2.98E-02	6.02E-04
27 Co 60	8.26E-01	7.60E-05	8.59E-02	9.75E+00	4.10E+00	3.16E-02	2.18E-09
27 Co 60	3.47E-01	7.50E-05	3.05E-01	3.46E+01	2.30E+00	3.21E-02	0
27 Co 60	7.48E-03	6.44E-05	2.71E+02	3.07E+04	1	1.22E+01	0
27 Co 60	7.46E-03	3.27E-05	2.72E+02	3.09E+04	1	1.23E+01	0
27 Co 60	8.26E-03	1.31E-05	2.11E+02	2.40E+04	1	9.01E+00	0
27 Co 60	2.16E+00	1.20E-05	4.54E-02	5.15E+00	3.90E+00	2.52E-02	6.78E-08
27 Co 60	8.50E-04	1.49E-06	7.16E+03	8.12E+05	1	5.38E+03	0
27 Co 60	2.51E+00	2.00E-08	4.39E-02	4.99E+00	3.35E+00	2.40E-02	1.26E-10

Download ☒ Excel ☐ CSV Separator: Semicolon (",") ☒ Use field qualifier (")

# Options and operation modes:

**Dosimetry and Shielding Settings**

**Energy range option:**

☐ Only Gamma    ☐ Only X-rays    ☒ Gamma and X-rays

☒ Threshold set

**Threshold energy (keV):**

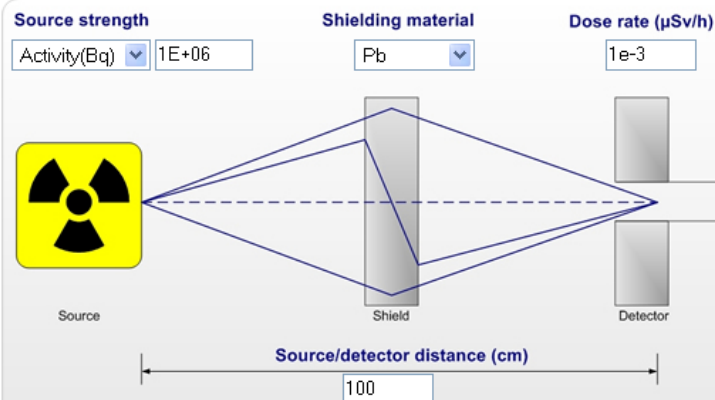
**Result Detail option:** ☒ Show Nuclides

**Mode of operation option:**

☒ Gamma Dose Rate  
☐ ShieldThickness

Element: Co Mass: 60 Nuclide Mixtures Selector

Dosimetry and Shielding Options



# Shield thickness mode:

Half-Value Shield Thickness(cm)	1.88E+00
Tenth-Value Shield Thickness(cm)	4.90E+00
Equivalent Dose Rate Constant Γ(mSv·m <sup>2</sup> /GBq/h)	3.37E-01
Shielding Thickness  required(cm)	1.09E+01
Resulting Gamma  Dose Rate(μSv/h)	1.00E-03

Gamma Energy (MeV)	Emission Probability P (per disintegration)	Mass Attenuation Coefficient (shielding)(cm <sup>2</sup> /g)	Number of Mean Free Path(μd)	Build-up Factor	Mass Absorption Coefficient (tissue)(cm <sup>2</sup> /g)	Gamma Dose Rate(μSv/h)
1.33E+00	1.00E+00	5.64E-02	7.00E+00	4.30E+00	2.89E-02	6.91E-04
1.17E+00	9.99E-01	6.20E-02	7.70E+00	4.30E+00	2.98E-02	3.10E-04
8.26E-01	7.60E-05	8.59E-02	1.07E+01	5.03E+00	3.16E-02	1.07E-09
3.47E-01	7.50E-05	3.05E-01	3.78E+01	2.35E+00	3.21E-02	0
7.48E-03	6.44E-05	2.71E+02	3.36E+04	1	1.22E+01	0
7.46E-03	3.27E-05	2.72E+02	3.38E+04	1	1.23E+01	0
8.26E-03	1.31E-05	2.11E+02	2.63E+04	1	9.01E+00	0
2.16E+00	1.20E-05	4.54E-02	5.63E+00	3.90E+00	2.52E-02	4.17E-08
8.50E-04	1.49E-06	7.16E+03	8.89E+05	1	5.38E+03	0
2.51E+00	2.00E-08	4.39E-02	5.46E+00	3.90E+00	2.40E-02	9.16E-11

## Help:Dosimetry & Shielding

In this section the formalism for dosimetry and shielding calculations is developed. In the physical basis of radiation dosimetry and shielding.

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- 1 Biological Effects of Ionising Radiation
- 2 Absorbed Dose
  - 2.1 Quality or Weighting Factor
  - 2.2 Equivalent Dose
  - 2.3 Effective Dose
  - 2.4 Committed Effective Dose, E(r)
  - 2.5 Collective Effective Dose
  - 2.6 Radiotoxicity and Annual Limits of Intake (ALI)
  - 2.7 Radiation Hormesis and the Linear Non-Threshold (LNT) Model
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- 9 The Gamma Dose Module
  - 9.1 User Interface
    - 9.1.1 Source/Detector Distance (cm)
    - 9.1.2 Source Strength
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# Wiki-based On-line Help

$\mu$  slope of the absorption curve – the attenuation coefficient.

Since the product  $\mu d$  in the above relation must be dimensionless, if the absorber thickness is measured in cm, then the attenuation coefficient is called the linear attenuation coefficient  $\mu_l$  and has dimension  $\text{cm}^{-1}$ . If the thickness  $d$  is in  $\text{g}/\text{cm}^2$  then the attenuation coefficient is called the mass attenuation coefficient  $\mu_m$  and has units of  $\text{cm}^2/\text{g}$ . The relationship between these coefficients is:

$$\mu_l (\text{cm}^{-1}) = \mu_m (\text{cm}^2/\text{g}) \cdot \rho (\text{g}/\text{cm}^3),$$

where  $\rho$  is the density of the absorber. The attenuation coefficient is the fraction of the gamma radiation beam attenuation per unit thickness of absorber and is defined as:

$$\mu = -[(\Delta I)/\Delta d]_{\Delta d \rightarrow 0},$$

where  $\Delta I/I$  is the fraction of the gamma radiation attenuated by an absorber of thickness  $\Delta d$ . The attenuation coefficient thus defined is sometimes called the total attenuation coefficient. Generally, for energies between about 0.75 and 5 MeV, almost all materials have, on a mass basis, about the same gamma radiation attenuation properties. To a first approximation, therefore, shielding properties are approximately proportional to the density of the shielding material. Under conditions of good geometry, the attenuation of a beam of gamma radiation is given therefore by:

$$I = I_0 \cdot \exp(-\mu d)$$

or

$$I = I_0 \cdot \exp[-(\mu/\rho) \cdot \rho d].$$

However, under conditions of poor geometry, i.e. for a broad beam or for a very thick shield, the above relation underestimates the required shield thickness. It assumes that every photon that interacts with the shield will be removed from the beam and thus will not be available for counting in the detector. Under conditions of poor geometry, as shown in Fig. 2, this assumption is not valid; a significant number of photons may be scattered by the shield into the detector, or photons that had been scattered out of the beam may be scattered back in after a second collision.

The shield thickness for conditions of poor geometry may be estimated by modification of the basic attenuation relation given above through the use of a build-up factor B, i.e.

$$I = B \cdot I_0 \cdot \exp[-(\mu/\rho) \cdot (\rho d)].$$

The build-up factor, which is always greater than 1, may be defined as the ratio of the intensity of the radiation, including both the primary and scattered radiation, at any point in a beam, to the intensity of the primary radiation only at that point. Build-up factors have been calculated for various gamma energies and for various absorbers. The build-up factor is in general a function of the total attenuation coefficient, the thickness of the shielding material  $d$ , and the energy of the gamma radiation, i.e.  $B = B(\mu, d, E_\gamma)$ .

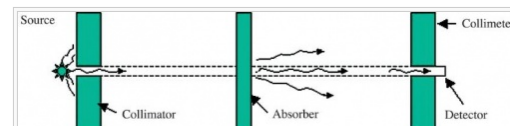


Fig.1. Measurement of the attenuation of gamma radiation under conditions of good geometry. Ideally, the beam should be well collimated, and the source should be as far away as possible from the detector. The absorber should be midway between the source and the detector, and it should be thin enough so that the likelihood of a second interaction between a photon already scattered by the absorber and the absorber is negligible. In addition, there should be no scattering material in the vicinity of the detector.

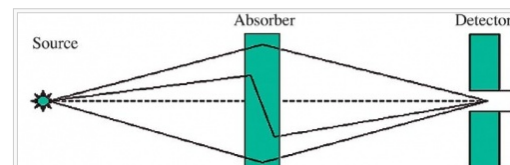


Fig.2. Gamma radiation attenuation under conditions of broad beam geometry showing the effect of photons scattered into the detector.

# Scripting language

Dosimetry	Description:	Performs dosimetry calculation
	Return type:	DoseResult
	Parameters:	<ul style="list-style-type: none"> <li>■ double quantity</li> <li>■ string unitQuantity ("Bq", "Ci", "g", "atoms")</li> <li>■ string energyRangeOption (comma seperated string consisting of values "gamma", "xray")</li> <li>■ string shieldMaterial, one of the following shield materials: "Pb", "Concrete", "Fe", "Sn", "W", "U", "Water", "Al", "Air", "Tissue"</li> <li>■ double distance [cm]</li> <li>■ string doseOption, the mode of calculation: "gamma", "thickness"</li> <li>■ double thickness [cm]</li> <li>■ double threshold [keV]</li> </ul>

```

***** U235 Dosimetry *****
HalfValueThickness 9.51E-05
TenthValueThickness 0.03
Equivalent dose rate constant 0.154
Gamma dose Rate 8.67E-16
Thickness 0
Resulting Gamma dose Rate 0
  
```

```

int main()
{
    nuclide nuc;
    nuc.Create("U", 235, 0);

    print("***** U235 Dosimetry *****");
    doseResult doseRes;
    doseRes = nuc.Dosimetry(1E6, "Bq", "gamma,xray", "Pb", 100, "gamma", 10, -1);
    print("HalfValueThickness " + doseRes.HalfValueThickness);
    print("TenthValueThickness " + doseRes.TenthValueThickness);
    print("Equivalent dose rate constant " + doseRes.EquiDoseRateConst);
    print("Gamma dose Rate " + doseRes.GammaDoseRate);
    doseRes = nuc.Dosimetry(1E6, "Bq", "gamma,xray", "Pb", 100, "thickness", 1E-6, 10);
    print("Thickness " + doseRes.Thickness);
    print("Resulting Gamma dose Rate " + doseRes.ResultingGammaDoseRate);
    print("");

    return 0;
}
  
```

## CONCLUSIONS

The Dosimetry and Shielding is:

- ✓ A versatile tool for quick and accurate dosimetry and shielding calculations.
- ✓ It allows the user to calculate gamma dose rates from point sources of single nuclide and mixtures, through a choice of 10 different shield materials. Over 3000 nuclides with more than 53000 gamma lines are available in the database.
- ✓ The intuitive interface allows quick and accurate calculations and has been specifically designed to be suitable for use by professionals and students in nuclear science and technology.
- ✓ Complete implementation in the Nucleonica framework (with Wiki/Help), and can be used within the scripting language.
- ✓ Continuously under development (more shielding material, multiple screens, volumetric sources...)

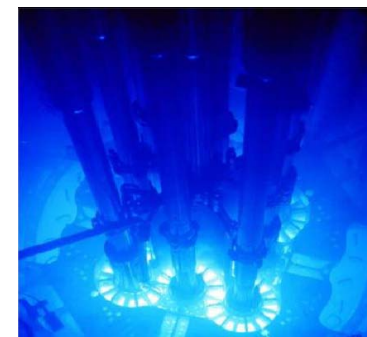
# RANGE AND STOPPING POWER CALCULATIONS IN NUCLEONICA



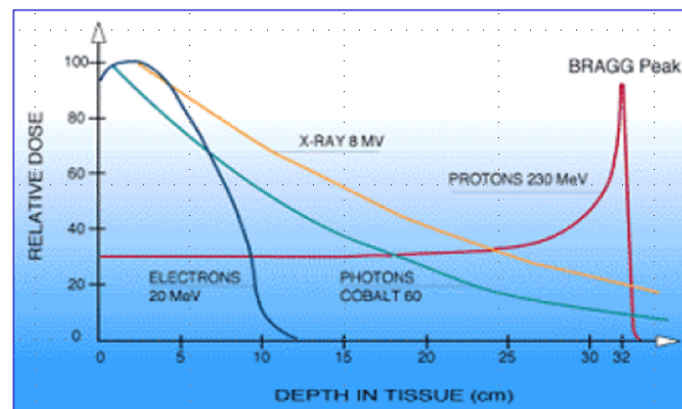
**Aurora Borealis:** interaction of electrons with oxygen and molecular nitrogen.



**Čerenkov radiation:** is radiation emitted when a charged particle) passes through matter at a speed greater than the speed of light in that medium. The characteristic "blue glow" of nuclear reactors is due to Čerenkov radiation.



**Proton therapy:** (used in treatment of tumours): 230 MeV p can penetrate in 32 cm tissue



wide application area: ion implantation, fundamental particle physics, nuclear physics, radiation damage, radiology, Rutherford backscattering spectroscopy, and plasma-first wall interaction in a nuclear-fusion reactor

## Projectile:

alpha  
electron  
positron  
proton  
alpha  
muon  
other ions

Energy (MeV)  
Energy (MeV)  
Energy (MeV)/amu  
Speed (m/s)  
Speed (w/c)

## Target: Mono-elements:

Actinium  
Aluminum  
Antimony  
Argon  
Arsenic  
Astatine  
Barium  
Beryllium  
Bismuth  
Boron  
Bromine  
Cadmium  
Calcium  
Carbon  
Cerium  
Cesium  
Chlorine  
Chromium  
Cobalt  
Copper  
Dysprosium  
Erbium  
Europium  
Fluorine  
Francium  
Gadolinium  
Gallium  
Germanium  
Gold  
Hafnium

## Main Interface:

### Range & Stopping Power

Input Details Compound Details Options

**Input**

Projectile

Projectile Ion: alpha

Energy (MeV): 200

**Target**

Actinium

Density (g/cm<sup>3</sup>): 10

☒ Mono-element  
☐ Predefined compound  
☐ User defined compound

☒ Solid  
☐ Gas

Run

## Target: User-Defined Compounds:

Input Details Compound Details Options

### Compound composition

User defined compound: sodium iodide Save Delete

Z	Element	Atomic Weight	Stoichiometry
53	Iodine	126.9000	1

Add Remove Remove All

	Z	Element	Atomic Weight	Stoichiometry	Atom %
Edit	11	Sodium	22.99	1	50
Edit	53	Iodine	126.9	1	50

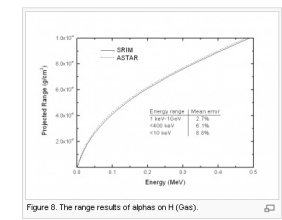
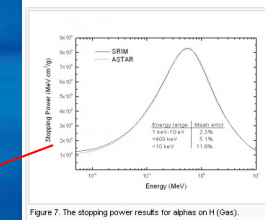
## Wiki Help:

**Test Results for Alphas**

In this section, we give the results of stopping power and ranges for alphas in H (gas), Pb (solid) and water (liquid). We have compared the results for RANGE module with those from ASTAR. Obtained results are shown in the figs.7-12 for these targets.

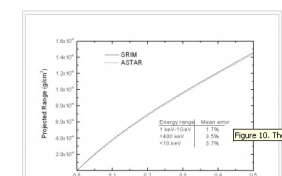
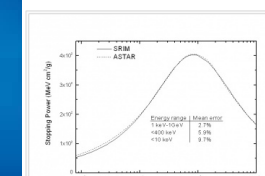
### Alphas in H (Gas)

Calculated results are shown in fig. 7 for stopping power and in fig. 8 for range. We have also given the mean errors in tables (see figs.7-8) for stopping power and for range, respectively.



### Alphas in Pb (Solid)

The calculations of stopping power and range for the alphas were carried out in Pb to test solid targets. Obtained results are shown in figs. 9 and 10 for stopping power and range, respectively. As can be seen from the figures, obtained results are quite agree with the results of ASTAR.



## Target: Pre-Defined Compounds:

Target

Acetone

Acetone  
Air (dry, near sea level)  
Aluminium oxide  
Ammonia  
Brass  
Bronze  
Concrete  
CR-39  
Glass (Pb transparent)  
Graphite (Carbon)  
Lexan  
Methanol  
Paraffin  
Photographic emulsion  
Plexiglass  
Scintillator NaI  
Skin human  
Soft Tissue (ICRP)  
Stainless steel  
Teflon  
Water (liquid)  
Water (vannum)

# Results:

```
=====
Calculation using SRIM-2006
SRIM version --->
Calc. date ---> April 07, 2008
=====

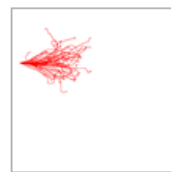
Disk File Name = range_out2.txt

Ion = Helium      [2] , Mass = 4.002603 amu

Density = 1.0000E+00 g/cm3 = 4.4282E+22 atoms/cm3
===== Target Composition =====
Atom  Atom  Atomic  Mass
Name  Numb  Percent Percent
-----
H      1     010.45   000.77
C      6     023.22   020.51
N      7     002.49   002.56
O      8     063.02   074.15
Na     11    000.11   000.19
Mg     12    000.01   000.02
P      15    000.13   000.30
S      16    000.20   000.47
Cl     17    000.13   000.35
K      19    000.20   000.57
Ca     20    000.02   000.07
Fe     26    000.01   000.02
Zn     30    000.00   000.01
=====
Bragg Correction = 0.00%
Stopping Units = keV/(mg/cm2)
See bottom of Table for other Stopping units

Ion = Helium      [2] , Mass = 4.002603 amu

Ion Energy  dE/dx Elec.  dE/dx Nuclear  Projected Range
-----
999.999 eV  9.609E+01      1.382E+02      224 A
1.10 keV   1.008E+02      1.364E+02      246 A
1.20 keV   1.053E+02      1.346E+02      267 A
1.30 keV   1.096E+02      1.328E+02      288 A
```



## Range & Stopping Power

Input Details Compound Details Options

**Input**

Projectile

Projectile Ion:

Energy (MeV):

Target

Target:

Density (g/cm<sup>3</sup>):

☐ Mono-element ☒ Solid

☒ Predefined compound ☐ Gas

☐ User defined compound

**Run**

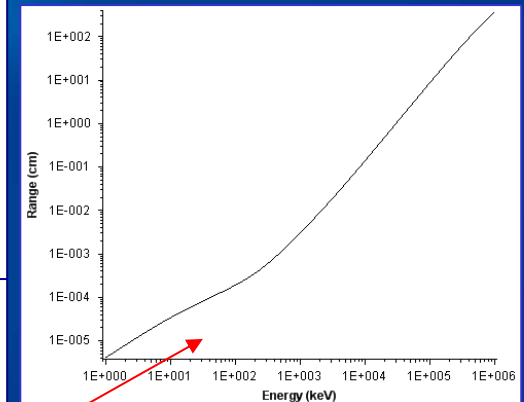
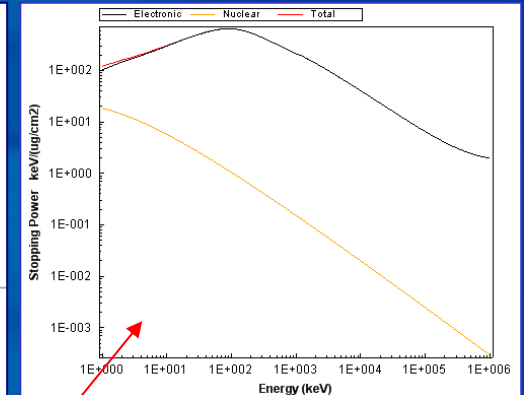
**Results**

Projected range, R: 4.460E+1  $\mu\text{m}$

Mass thickness: 4.460E-3 g/cm<sup>2</sup>

Stopping Power (total): 7.669E+2 keV/(mg/cm<sup>2</sup>)


Table Graph SP Graph Range



nucleonica



- Target: User-defined compounds



## Range & Stopping Power

Input

Details

Compound Details

Options

### Compound composition

User defined compound

Z

Element

Atomic Weight

Stoichiometry

▼

▼

	Z	Element	Atomic Weight	Stoichiometry	Atom %
Edit	1	Hydrogen	1.008	4	80
Edit	6	Carbon	12.011	1	20

nucleonica



# Wiki Help:

## Range Calculations

[edit]

Most of the transport calculations and Monte Carlo simulations for the calculation of Range are based on the so-called Continuous Slowing Down Approximation (CSDA). In this approximation, it is assumed that the particle loses its energy in a continuous way and at a rate equal to the stopping power. Since the stopping power is the energy loss of projectile per unit path, CSDA range (or Bethe range) is calculated by

$$R(E) = \int_{E_{abs}}^E \frac{dE'}{S(E')}$$

where  $E_{abs}$  is the energy where particle is effectively absorbed. CSDA range is the path length traveled by the particle and since energy-loss fluctuations are not considered, CSDA range is always higher than projected range ( $R_p$ ) which is the distance between the point where particle enters the stopping medium and the point where particle is absorbed (or come to rest). It becomes important when the projectile's energy is low enough.

SRIM uses PRAL (Projected Range ALgorithm) [6] equations for calculating projected range. To second order it involves iterating the difference equation

$$R_p(E_0 + \Delta E_0) = R_p(E_0) + \left[ \frac{4E^2 - (2E\mu S_n + \mu Q_n)R_p(E_0)}{4ES_t - 2\mu Q_n} \right] \frac{\Delta E_0}{E}$$

## Test Results for Protons

[edit]

We calculated the stopping powers and ranges of H (Gas), Pb (solid) and water (Liquid) for protons and compared the results with PSTAR.

### Protons on H (Gas)

[edit]

As can be seen in fig.1, overall agreement with PSTAR is quite good. Comparing the RANGE module's results with PSTAR, the overall mean error in energy range from 1 keV to 1 GeV is 0.8 %, mean error is 1.8 % in energies below 400 keV and mean error in energies below 10 keV is 2.5 %.

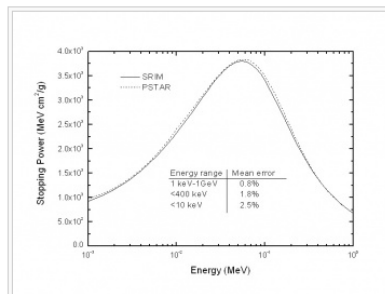


Figure 1. The stopping power results for protons in H (Gas).

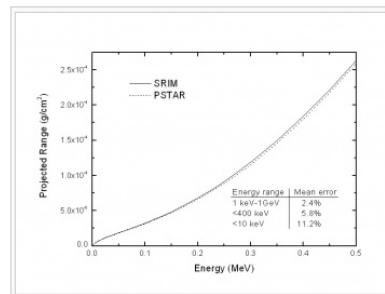


Figure 2. The range results of protons in H (Gas).



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## Range and Stopping power

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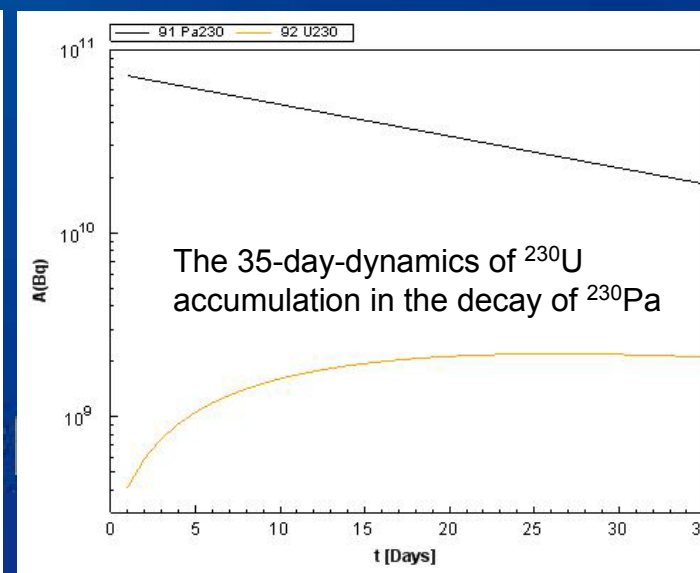
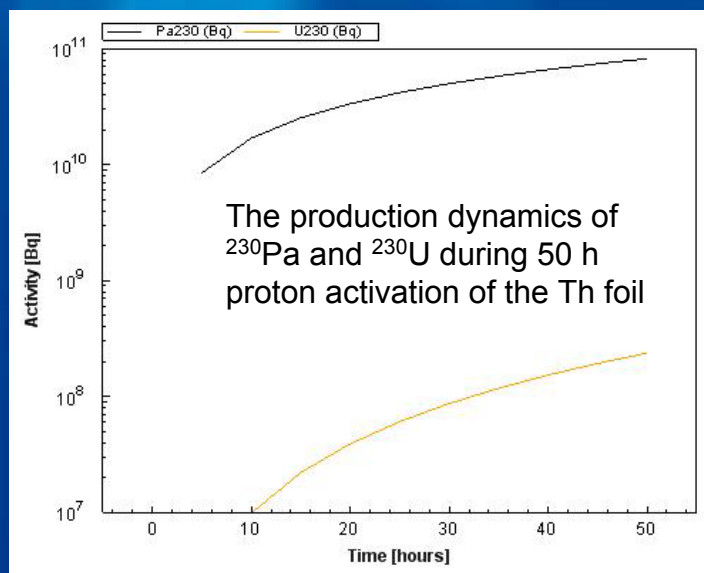
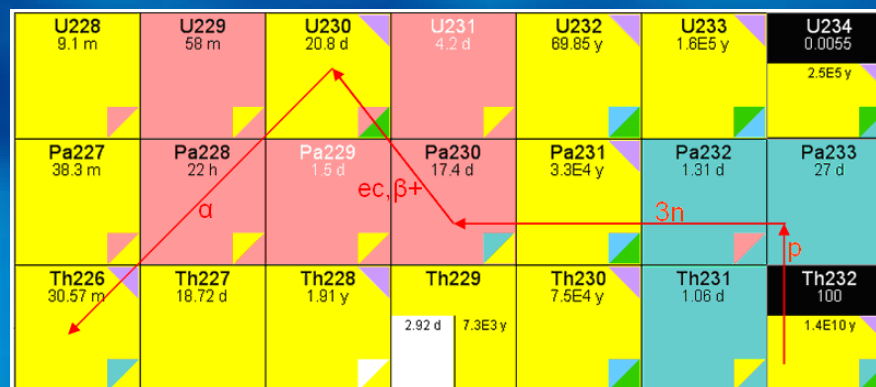
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    - 6.3.3 Electrons in Water (Liquid)
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    - 6.4.2 Positrons in Pb (solid)
    - 6.4.3 Positrons in water (liquid)
  - 6.5 Test Results for Muons
    - 6.5.1 Muons in H (gas)
    - 6.5.2 Muons in Pb (solid)
    - 6.5.3 Muons in water (liquid)
- 7 Using Range&Stopping Power Module

# Range Calculations with Nucleonica Scripting

## Scripting language:

Classes	Main Methods
<i>range</i>	<i>CalculateMono()</i>
	<i>CalculateCompound()</i>
	<i>CalculatePredefinedCompound()</i>
	<i>AddCompound()</i>
	<i>OriginConfigureSP()</i>
	<i>OriginGraphSP()</i>
	<i>OriginConfigureRange()</i>
	<i>OriginGraphRange()</i>
<i>rangeResult</i>	<i>ProjRange(); massthickness();</i>
	<i>StragLong(); StragLat(); etc.</i>

## Case Study: The isotope pair $^{230}\text{U}/^{226}\text{Th}$ as a candidate for targeted alpha therapy - optimization of $^{230}\text{U}$ production



# CONCLUSIONS

- The RANGE module:
- provides a user-friendly interface for quick and accurate calculations on the range and stopping powers of charged particles.
- can calculate SP and Range for electrons, positrons, protons, alphas, muons and heavy ions in a variety of different natural elements, pre-defined and user-defined compounds.
- Test results show agreements of less than 5% for protons and alphas, less than 10% for electrons and positrons, and less than 7% for muons for the total stopping powers and the CSDA Ranges. The Range module uses SRIM for heavy particles with a known accuracy of less than 5%.
- give freedom to the user for selecting the energy and stopping power units.
- provides high quality graphs for SP and Range.
- can be used in the Nucleonica scripting language.



... web driven nuclear science

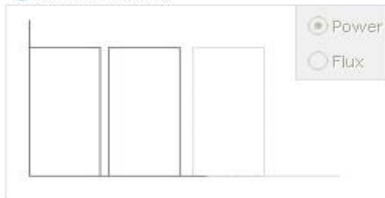
Applications My Preferences Print Help



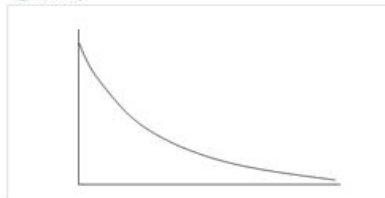
webKORIGEN

Step 1: Calculation Mode Step 2: Reactor / Operation Step 3: Input Summary and Run Step 4: Display Result

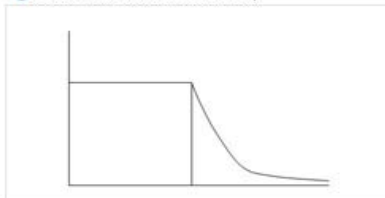
☐ Reactor irradiation



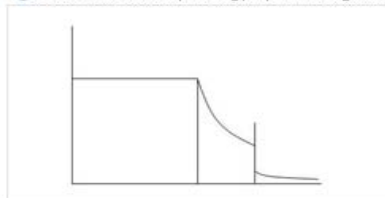
☐ Decay



☒ Reactor irradiation and decay



☐ Reactor irradiation, cooling, reprocessing and decay



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Step 1: Calculation Mode Step 2: Reactor / Operation Step 3: Input Summary and Run Step 4: Display Result

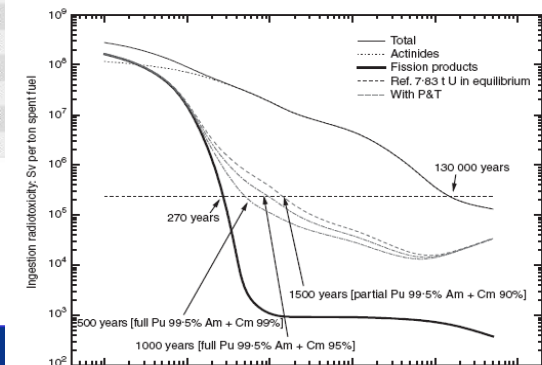
Display Results at 6 y for most important nuclides

Display quantity: Activity (Bq)

Top Nuclides	Results	Top Elements	Results	Totals	Results
Cs137	1.095E+17	Cesium	1.401E+17	Actinides:	1.130E+17
Ba137m	1.036E+17	Plutonium	1.054E+17	Fission Prod.	4.670E+17
Pu241	9.937E+16	Barium	1.036E+17	Total	5.800E+17
Y90	7.129E+16	Yttrium	7.129E+16		
Sr90	7.127E+16	Strontium	7.127E+16		
Cs134	3.065E+16	Promethium	2.917E+16		
Pm147	2.917E+16	Europium	1.209E+16		
Eu154	9.611E+15	Ruthenium	9.449E+15		
Rh106	9.449E+15	Rhodium	9.449E+15		
Ru106	9.449E+15	Krypton	7.199E+15		
Kr85	7.199E+15	Curium	6.249E+15		
Cm244	6.205E+15	Praseodymium	4.031E+15		
Pu238	5.291E+15	Cerium	3.983E+15		
Ce144	3.983E+15	Antimony	3.670E+15		
Pr144	3.983E+15	Americium	1.313E+15		
Sb125	3.669E+15	Tellurium	8.950E+14		
Eu155	2.477E+15	Neptunium	4.048E+13		
Am241	1.259E+15				
Te125m	8.950E+14				
Pu240	4.933E+14				

Neutron and gamma rates  
Neutron rate: 2.491E+10 n/s  
Gamma rate from Actinides: 6.427E+13 MeV/s

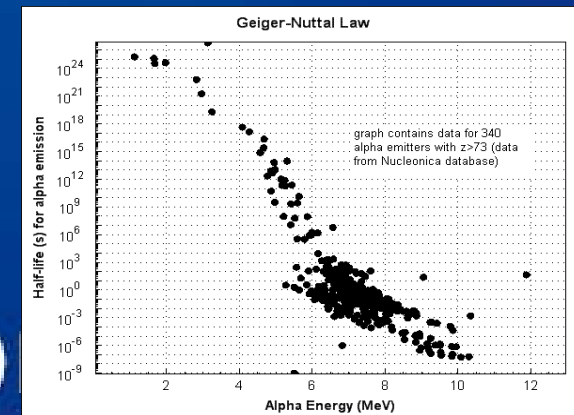
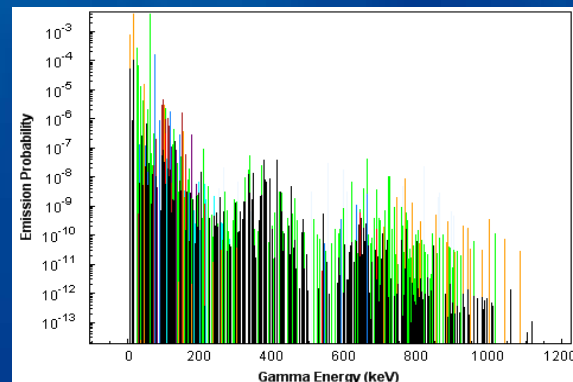
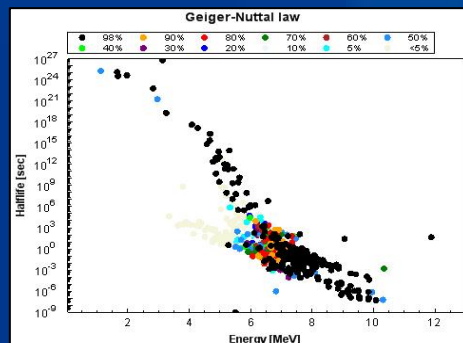
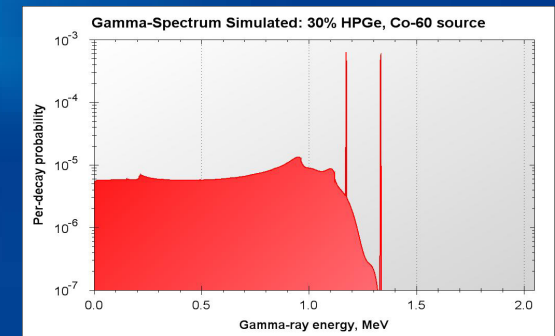
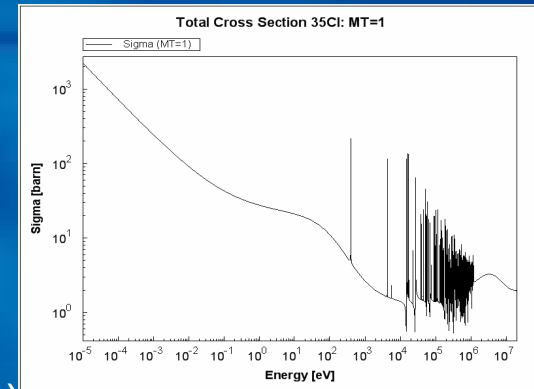
# Highlight: webKORIGEN



# webGraphics...

## The Nucleonica webGraphics Features:

- No need to buy expensive commercial software
- Easy to use
- Delivers publication quality scientific graphs
- Variety of formats available (gif, jpg, emf, eps, png, svg)
- Graphics configuration can be stored for future use
- Available at any time from any location
- Under constant further development



# Conclusions: Key Advantages of Nucleonica

- Keep informed with the latest news on nuclear issues
- Use internationally evaluated nuclear data in your work
- Extensive range of nuclear science applications
- Manage all your data in a single browser-based system and keep track of your recent activities
- Prepare a lecture or a training course with Nucleonica materials (graphics. etc.)
- Prepare publication quality scientific graphs
- Stay in contact with your colleagues from previous employment, workshops or conferences
- Meet scientists from your areas of interest and build up an international contact list and represent yourself and your Institute/Organisation in the international science community



nucleonica



Thanks!



nucleonica

